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XLIV. *Of the stilling of Waves by means of Oil. Extracted from sundry Letters between Benjamin Franklin, LL. D. F. R. S. William Brownrigg, M. D. F. R. S. and the Reverend Mr. Farish.*

Extract of a Letter from Doctor BROWNRIGG to Dr. FRANKLIN, dated Ormathwait, January 27, 1773.

Reide, June 2, 1774. **B**Y the enclosed from an old friend, a worthy clergyman at Carlisle, whose great learning and extensive knowledge in most sciences would have more distinguished him, had he been placed in a more conspicuous point of view, you will find that he had heard of your experiment on Derwent Lake, and has thrown together what he could collect on that subject; to which I have subjoined one experiment from the relation of another Gentleman.

Extract of a Letter from the Reverend Mr. FARISH, to Dr. BROWNRIGG.

I some time ago met with Mr. Dun, who surprised me with an account of an experiment you had tried upon the Derwent water, in company with
Sir

Sir JOHN PRINGLE and Dr. FRANKLIN. According to his representation, the water, which had been in great agitation before, was instantly calmed, upon pouring in only a very small quantity of oil, and that to so great a distance round the boat as seems a little incredible. I have since had the same accounts from others, but I suspect all of a little exaggeration. PLINY mentions this property of oil as known particularly to the divers, who made use of it in his days, in order to have a more steady light at the bottom(a). The sailors, I have been told, have observed something of the same kind in our days, that the water is always remarkably smoother in the wake of a ship that hath been newly tallowed, than it is in one that is foul. — Mr. PENNANT also mentions an observation of the like nature made by the seal catchers in Scotland. *Brit. Zool.* Vol. IV. *Article* SEAL. When these animals are devouring a very oily fish, which they always do under water, the waves above are observed to be remarkably smooth, and by this mark the fishermen know where to look for them. — Old PLINY does not usually meet with all the credit I am inclined to think he deserves. I shall be glad to have an authentic account of the Keswick experiment, and if

Note by Dr. BROWNRIGG.

(a) Sir GILFRED LAWSON, who served long in the army at Gibraltar, assures me that the fishermen in that place are accustomed to pour a little oil on the sea, in order to still its motion, that they may be enabled to see the oysters lying at its bottom; which are there very large, and which they take up with a proper instrument. This Sir GILFRED had often seen there performed, and said the same was practised on other parts of the Spanish coast.

it

it comes up to the representations that have been made of it, I shall not much hesitate to believe the old Gentleman in another more wonderful phenomenon, he relates, of stilling a tempest only by throwing up a little vinegar into the air.

Extract of a Letter to Doctor BROWNRIGG from
Doctor FRANKLIN.

London, Nov. 7, 1773.

DEAR SIR,

I thank you for the remarks of your learned friend at Carlisle. — I had, when a youth, read and smiled at PLINY'S account of a practice among the seamen of his time, to still the waves in a storm by pouring oil into the sea; which he mentions, as well as the use made of oil by the divers; but the stilling a tempest by throwing vinegar into the air had escaped me. I think with your friend, that it has been of late too much the mode to slight the learning of the antients. The learned, too, are apt to slight too much the knowledge of the vulgar. The cooling by evaporation was long an instance of the latter. This art of smoothing the waves with oil, is an instance of both.

Perhaps you may not dislike to have an account of all I have heard, and learnt, and done in this way. Take it if you please as follows.

In 1757, being at sea in a fleet of 96 sail bound against Louisbourg, I observed the wakes of two of the ships to be remarkably smooth, while all the others were ruffled by the wind, which blew fresh. Being puzzled with the differing appearance, I at last pointed

pointed it out to our captain, and asked him the meaning of it? "The cooks, says he, have, I suppose, been just emptying their greasy water through the scuppers, which has greased the sides of those ships a little;" and this answer he gave me with an air of some little contempt, as to a person ignorant of what every body else knew. In my own mind I at first slighted his solution, tho' I was not able to think of another. But recollecting what I had formerly read in *PLINY*, I resolved to make some experiment of the effect of oil on water, when I should have opportunity.

Afterwards being again at sea in 1762, I first observed the wonderful quietness of oil on agitated water, in the swinging glass lamp I made to hang up in the cabin, as described in my printed papers, page 438 of the fourth edition. — This I was continually looking at and considering, as an appearance to me inexplicable. An old sea captain, then a passenger with me, thought little of it, supposing it an effect of the same kind with that of oil put on water to smooth it, which he said was a practice of the *BERMUDIANS* when they would strike fish, which they could not see, if the surface of the water was ruffled by the wind. This practice I had never before heard of, and was obliged to him for the information; tho' I thought him mistaken as to the sameness of the experiment, the operations being different; as well as the effects. In one case, the water is smooth till the oil is put on, and then becomes agitated. In the other it is agitated before the oil is applied, and then becomes smooth. — The same gentleman told me, he had heard it was a practice with the fishermen

men of LISBON when about to return into the river, (if they saw before them too great a surf upon the bar, which they apprehended might fill their boats in passing) to empty a bottle or two of oil into the sea, which would suppress the breakers, and allow them to pass safely : a confirmation of this I have not since had an opportunity of obtaining. But discouraging of it with another person, who had often been in the Mediterranean, I was informed that the divers there, who, when under water in their business, need light, which the curling of the surface interrupts by the refractions of so many little waves, let a small quantity of oil now and then out of their mouths, which rising to the surface smooths it, and permits the light to come down to them. — All these informations I at times revolved in my mind, and wondered to find no mention of them in our books of experimental philosophy.

At length being at CLAPHAM where there is, on the common, a large pond, which I observed to be one day very rough with the wind, I fetched out a cruet of oil, and dropt a little of it on the water. I saw it spread itself with surprizing swiftness upon the surface ; but the effect of smoothing the waves was not produced ; for I had applied it first on the leeward side of the pond, where the waves were largest, and the wind drove my oil back upon the shore. I then went to the windward side, where they began to form ; and there the oil, though not more than a tea spoonful, produced an instant calm over a space several yards square, which spread amazingly, and extended itself gradually till it reached the lee side, making all that quarter of the pond, perhaps half an acre, as smooth as a looking-glass.

After this, I contrived to take with me, whenever I went into the country, a little oil in the upper hollow joint of my bamboo cane, with which I might repeat the experiment as opportunity should offer; and I found it constantly to succeed.

In these experiments, one circumstance struck me with particular surprize. This was the sudden, wide, and forcible spreading of a drop of oil on the face of the water, which I do not know that any body has hitherto considered. If a drop of oil is put on a polished marble table, or on a looking-glass that lies horizontally; the drop remains in its place, spreading very little. But when put on water it spreads instantly many feet round, becoming so thin as to produce the prismatic colours, for a considerable space, and beyond them so much thinner as to be invisible, except in its effect of smoothing the waves at a much greater distance. It seems as if a mutual repulsion between its particles took place as soon as it touched the water, and a repulsion so strong as to act on other bodies swimming on the surface, as straws, leaves, chips, &c. forcing them to recede every way from the drop, as from a center, leaving a large clear space. The quantity of this force, and the distance to which it will operate, I have not yet ascertained; but I think it a curious enquiry, and I wish to understand whence it arises.

In our journey to the north, when we had the pleasure of seeing you at Ormathwaite, we visited the celebrated Mr. SMEATON near Leeds. Being about to shew him the smoothing experiment on a little pond near his house, an ingenious pupil of his, Mr. Jessop, then present, told us of an odd appearance on that pond,

which had lately occurred to him. He was about to clean a little cup in which he kept oil, and he threw upon the water some flies that had been drowned in the oil. These flies presently began to move, and turned round on the water very rapidly, as if they were vigorously alive, though on examination he found they were not so. I immediately concluded that the motion was occasioned by the power of the repulsion abovementioned, and that the oil issuing gradually from the spongy body of the fly continued the motion. He found some more flies drowned in oil, with which the experiment was repeated before us. To shew that it was not any effect of life recovered by the flies, I imitated it by little bits of oiled chips and paper cut in the form of a comma, of the size of a common fly; when the stream of repelling particles issuing from the point, made the comma turn round the contrary way. This is not a chamber experiment; for it cannot well be repeated in a bowl or dish of water on a table. A considerable surface of water is necessary to give room for the expansion of a small quantity of oil. In a dish of water, if the smallest drop of oil be let fall in the middle, the whole surface is presently covered with a thin greasy film proceeding from the drop; but as soon as that film has reached the sides of the dish, no more will issue from the drop, but it remains in the form of oil, the sides of the dish putting a stop to its dissipation by prohibiting the farther expansion of the film.

Our friend Sir JOHN PRINGLE being soon after in Scotland, learnt there, that those employed in the herring fishery, could at a distance see where the shoals of herrings were, by the smoothness of the

water over them, which might possibly be occasioned, he thought, by some oiliness proceeding from their bodies.

A gentleman from Rhode-island told me, it had been remarked that the harbour of Newport was ever smooth while any whaling vessels were in it; which probably arose from hence, that the blubber which they sometimes bring loose in the hold, or the leakage of their barrels, might afford some oil, to mix with that water, which from time to time they pump out to keep the vessel free, and that same oil might spread over the surface of the water in the harbour, and prevent the forming of any waves.

This prevention I would thus endeavour to explain.

There seems to be no natural repulsion between water and air, such as to keep them from coming into contact with each other. Hence we find a quantity of air in water; and if we extract it by means of the air-pump, the same water again exposed to the air, will soon imbibe an equal quantity.

Therefore air in motion, which is wind, in passing over the smooth surface of water, may rub, as it were, upon that surface, and raise it into wrinkles, which, if the wind continues, are the elements of future waves.

The smallest wave once raised does not immediately subside, and leave the neighbouring water quiet: but in subsiding raises nearly as much of the water next to it, the friction of the parts making little difference. Thus a stone dropt in a pool raises first a single wave round itself; and leaves it, by sinking to the bottom; but that first wave subsiding raises a second, the second a third, and so on in circles to a great extent.

A small

A small power continually operating will produce a great action. A finger applied to a weighty suspended bell, can at first move it but little; if repeatedly applied, though with no greater strength, the motion increases till the bell swings to its utmost height, and with a force that cannot be resisted by the whole strength of the arm and body. Thus the small first-raised waves, being continually acted upon by the wind, are, though the wind does not increase in strength, continually increased in magnitude, rising higher and extending their bases, so as to include a vast mass of water in each wave, which in its motion acts with great violence.

But if there be a mutual repulsion between the particles of oil, and no attraction between oil and water, oil dropt on water will not be held together by adhesion to the spot whereon it falls; it will not be imbibed by the water; it will be at liberty to expand itself; and it will spread on a surface that, besides being smooth to the most perfect degree of polish, prevents, perhaps by repelling the oil, all immediate contact, keeping it at a minute distance from itself; and the expansion will continue, till the mutual repulsion between the particles of the oil is weakened and reduced to nothing by their distance.

Now I imagine that the wind blowing over water thus covered with a film of oil, cannot easily *catch* upon it, so as to raise the first wrinkles, but slides over it, and leaves it smooth as it finds it. It moves a little the oil indeed, which, being between it and the water, serves it to slide with, and prevents friction, as oil does between those parts of a machine, that would otherwise rub hard together. Hence the
oil

oil dropt on the windward side of a pond proceeds gradually to leeward, as may be seen by the smoothness it carries with it, quite to the opposite side. For the wind being thus prevented from raising the first wrinkles that I call the elements of waves, cannot produce waves, which are to be made by continually acting upon and enlarging those elements, and thus the whole pond is calmed.

Totally therefore we might suppress the waves in any required place, if we could come at the windward place where they take their rise. This in the ocean can seldom if ever be done. But perhaps something may be done on particular occasions, to moderate the violence of the waves, when we are in the midst of them, and prevent their breaking, where that would be inconvenient.

For when the wind blows fresh, there are continually rising on the back of every great wave, a number of small ones, which roughen its surface, and give the wind hold, as it were, to push it with greater force. This hold is diminished by preventing the generation of those small ones. And possibly too, when a wave's surface is oiled, the wind, in passing over it, may rather in some degree press it down, and contribute to prevent its rising again, instead of promoting it.

This as mere conjecture would have little weight, if the apparent effects of pouring oil into the midst of waves were not considerable, and as yet not otherwise accounted for.

When the wind blows so fresh, as that the waves are not sufficiently quick in obeying its impulse, their tops being thinner and lighter are pushed forward,
broken,

broken, and turned over in a white foam. Common waves lift a vessel, without entering it; but these when large sometimes break above and pour over it, doing great damage.

That this effect might in any degree be prevented, or the height and violence of waves in the sea moderated, we had no certain account; PLINY's authority for the practice of seamen in his time being flighted. But discoursing lately on this subject with his excellency Count BENTINCK of Holland, his son the honourable Captain BENTINCK, and the learned professor ALLEMAND, (to all whom I shewed the experiment of smoothing in a windy day the large piece of water at the head of the Green Park;) a letter was mentioned which had been received by the Count from Batavia, relative to the saving of a Dutch ship in a storm, by pouring oil into the sea. I much desired to see that letter, and a copy of it was promised me, which I afterward received ^(b).

(b) Extrait d'une Lettre de Mr. TENGNAGEL à Mr. le Comte de BENTINCK, écrite de Batavia le 15 Janvier, 1770.

Près des isles Paulus & Amsterdam nous effuiames un orage, qui n'eut rien d'assez particulier pour vous être marqué, si non que notre capitaine se trouva obligé en tournant sous le vent, de verser de l'huile contre la haute mer, pour empêcher les vagues de se briser contre le navire, ce qui réussit à nous conserver, & a été d'un très bon effet: comme il n'en versa qu'une petite quantité à la fois, la compagnie doit peut-être son vaisseau à six demi aumes d'huile d'olive: j'ai été présent quand cela s'est fait, & je ne vous aurois pas entretenu de cette circonstance, si ce n'étoit que nous avons trouvé les gens ici si prévenus contre l'expérience, que les officiers du bord ni moi n'avons fait aucune difficulté de donner un certificat de la vérité sur ce chapitre.

Extrait

“ Extract of a Letter from Mr. TENGNAGEL to
 “ Count BENTINCK, dated at Batavia the 5th
 “ of January 1770.

“ Near the islands Paul and Amsterdam, we met
 “ with a storm, which had nothing particular in it
 “ worthy of being communicated to you, except
 “ that the captain found himself obliged, for great-
 “ er safety in wearing the ship, to pour oil into the
 “ sea, to prevent the waves breaking over her, which
 “ had an excellent effect, and succeeded in preserv-
 “ ing us. — As he poured out but a little at a time,
 “ the East India company owes perhaps its ship to
 “ only six demi-aumes of oil olive. I was present
 “ upon deck when this was done ; and I should not
 “ have mentioned this circumstance to you, but that
 “ we have found people here so prejudiced against
 “ the experiment, as to make it necessary for the
 “ officers on board and myself to give a certificate of
 “ the truth on this head, of which we made no
 “ difficulty.”

On this occasion, I mentioned to Captain BENTINCK,
 a thought which had occurred to me in reading the
 voyages of our late circumnavigators, particularly
 where accounts are given of pleasant and fertile
 islands which they much desired to land upon, when
 sickness made it more necessary, but could not ef-
 fect a landing through a violent surf breaking on
 the shore, which rendered it impracticable. My
 idea was, that possibly by sailing to and fro at some
 distance from such lee shore, continually pouring oil
 into

into the sea, the waves might be so much depressed and lessened before they reached the shore as to abate the height and violence of the surff, and permit a landing; which, in such circumstances, was a point of sufficient importance to justify the expence of the oil that might be requisite for the purpose. That gentleman, who is ever ready to promote what may be of public utility, though his own ingenious inventions have not always met with the countenance they merited, was so obliging as to invite me to Portsmouth, where an opportunity would probably offer, in the course of a few days, of making the experiment on some of the shores about Spithead, in which he kindly proposed to accompany me, and to give assistance with such boats as might be necessary. Accordingly, about the middle of October last, I went with some friends to PORTSMOUTH; and a day of wind happening, which made a lee-shore between HASLAR HOSPITAL and the Point near JILLKECKER, we went from the Centaur with the long-boat and barge towards that shore. Our disposition was this: the long-boat was anchored about a quarter of a mile from the shore; part of the company were landed behind the Point (a place more sheltered from the sea) who came round and placed themselves opposite to the long-boat, where they might observe the surff, and note if any change occurred in it, upon using the oil. Another party, in the barge, plyed to windward of the long-boat, as far from her as she was from the shore, making trips of about half a mile each, pouring oil continually out of a large stone-bottle, through a hole in the cork, somewhat bigger than a goose-quill.

The experiment had not, in the main point, the success we wished, for no material difference was observed in the height or force of the surf upon the shore; but those who were in the long-boat could observe a tract of smoothed water, the whole length of the distance in which the barge poured the oil, and gradually spreading in breadth towards the long-boat. I call it smoothed, not that it was laid level; but because, though the swell continued, its surface was not roughened by the wrinkles, or smaller waves, before-mentioned; and none, or very few white-caps (or waves whose tops turn over in foam) appeared in that whole space, though to windward and leeward of it there were plenty; and a wherry, that came round the point under sail, in her way to Portsmouth, seemed to turn into that tract of choice, and to use it from end to end, as a piece of turn-pike-road.

It may be of use to relate the circumstances even of an experiment that does not succeed, since they may give hints of amendment in future trials: it is therefore I have been thus particular. I shall only add what I apprehend may have been the reason of our disappointment.

I conceive, that the operation of oil on water is, first, to prevent the raising of new waves by the wind; and, secondly, to prevent its pushing those before raised with such force, and consequently their continuance of the same repeated height, as they would have done, if their surface were not oiled. But oil will not prevent waves being raised by another power, by a stone, for instance, falling into a still pool; for they then rise by the mechanical impulse
of

of the stone, which the greasiness on the surrounding water cannot lessen or prevent, as it can prevent the winds catching the surface and raising it into waves. Now waves once raised, whether by the wind or any other power, have the same mechanical operation, by which they continue to rise and fall, as a *pendulum* will continue to swing, a long time after the force ceases to act by which the motion was first produced: that motion will, however, cease in time; but time is necessary. Therefore, though oil spread on an agitated sea, may weaken the push of the wind on those waves whose surfaces are covered by it, and so, by receiving less fresh impulse, they may gradually subside; yet a considerable time, or a distance through which they will take time to move, may be necessary to make the effect sensible on any shore in a diminution of the surf: for we know, that when wind ceases suddenly, the waves it has raised do not as suddenly subside, but settle gradually, and are not quite down till long after the wind has ceased. So though we should, by oiling them, take off the effect of wind on waves already raised, it is not to be expected that those waves should be instantly levelled. The motion they have received will, for some time, continue; and, if the shore is not far distant, they arrive there so soon, that their effect upon it will not be visibly diminished. Possibly, therefore, if we had begun our operations at a greater distance, the effect might have been more sensible. And perhaps we did not pour oil in sufficient quantity. Future experiments may determine this.

I was, however, greatly obliged to Captain BENTINCK, for the chearful and ready aids he gave me : and I ought not to omit mentioning Mr. BANKS, Dr. SOLANDER, General CARNAC, and Dr. BLAGDEN, who all assisted at the experiment, during that blustering unpleasant day, with a patience and activity that could only be inspired by a zeal for the improvement of knowledge, such especially as might possibly be of use to men in situations of distress.

I would wish you to communicate this to your ingenious friend, Mr. FARISH, with my respects ; and believe me to be, with sincere esteem,

DEAR SIR,

Your most obedient humble servant,

B. FRANKLIN.